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## TWO PARASITIC MUSHROOMS

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(WITH PLATES 177-179, CONTAINING 14 FIGURES)

### VOLVARIA LOWEIANA (Berk.) Pat.

Specimens of this parasite on *Clitocybe nebularis* were found by a member of the Minnesota Mycological Society in the autumn of 1915 and sent to me by the president of the Society, Dr. Mary S. Whetstone. Several collections both of the parasite and the uninfected host plant were received, from which the accompanying photographs were made. The plants grew in an area about ten feet square on the ground among leaves about a cluster of waxberry bushes. The host mushrooms had been collected from this locality and eaten for four years, but the parasite did not appear until the present season.

The host plants are deformed by the parasite and become irregular masses, like the so-called abortive forms of *Clitopilus abortivus* and *Armillaria mellea*. Whether their structure is similar to that of the host of *Pilosace algeriensis* described below could not be determined from my specimens. The illustrations of the European plants show less malformation of the host. The *Volvaria* appears as small, white, spherical bodies on the pileus of the host and has a normal development like that of *Volvaria bombycina*.

The specimens agree in all essential characters with Maire's description in the Bull. Soc. Myc. de France, Tome XXVII, fasc. 4, and I can add little from my material. The spore measure-

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ments agree with those given by Maire,  $4-5 \times 6-7 \mu$ , much larger than those reported in the Sylloge, by Stevenson, etc.

Pileus 1-2 inches broad, ovoid or globose, becoming companulate and expanded, obtuse, broadly umbonate, villous-silky, dry, not striate, fimbriate on the involute margin, white; flesh solid, white or with a tinge of pink; lamellae slightly ventricose, attenuated in each direction but somewhat broader in front, free, white-floccose on the edges, becoming pink and finally reddish with spores; stem about 2 inches long, 2-3 lines thick, slightly bulbous at the base, equal or somewhat attenuated upward, solid, white, fibrillose; volva white, covering the bulbous base of the stem, free margin short, lobed; spores pink to reddish in mass, ovoid or ellipsoid,  $4-5 \times 6-7 \mu$ , membrane thick, vacuoles one or two; basidia club-shaped, enlarged below the apex,  $7 \times 30 \mu$ , contents granular; cystidia numerous especially on the edges of the lamellae, ventricose, acuminate above with a cylindrical obtuse apex,  $8-15 \times 45-70 \mu$ .

Parasitic on *Clitocybe nebularis*.

Quélet considered *Volvaria Loweiana* as a luxuriant parasitic form of *Volvaria plumulosa* Lasch. The latter grows on the ground among humus in fir woods. Maire, who has studied both forms, agrees as to the identity of the two species, though he finds some minor differences between them. The most important difference is that the spores of *Volvaria plumulosa* are a little broader and shorter than those of *Volvaria Loweiana* but, as both Patouillard and Britzelmayer give the spore measurements of *Volvaria plumulosa* fully as long as those of *Volvaria Loweiana*, he concludes that the size of the spores may be variable. Maire gives photographs of both the parasitic and terrestrial form. The group includes *Volvaria Loweiana* (Berk.), *Volvaria plumulosa* (Lasch), *Volvaria parvula* var. *major* Wein., and *Volvaria hypofitys* Fries.

I collected plants of this group on the ground under coniferous trees at Frankfort, Mich., in August, 1911, but did not secure a photograph of the fresh plants. The dried specimens are shown in *pl. 177, f. C*. They agree with *Volvaria plumulosa* as described and illustrated by Maire. The plants were white with a villous, silky pileus, even, not striate on the margin. The stem was silky-fibrillose, solid, slightly bulbous at the base, where it was covered

by the white volva. The plants were less robust and a little smaller than *Volvaria Loweiana*. Most of the spores were  $4-5 \times 5-6 \mu$  agreeing with Maire's observation though many spores  $7 \mu$  in length were to be found. The basidia and cystidia in the two plants agreed exactly, which is especially significant in the case of the cystidia which have a peculiar shape. The plants are certainly closely related, though cultures would be necessary to prove their identity. This would be difficult to accomplish with such rare plants. Worthington Smith succeeded in growing *Volvaria Loweiana* on *Clitocybe nebularis*.

The limits of the group in this country are not well fixed. Several forms should be kept in mind by collectors.

1. *Volvaria villosa-volva* Lloyd, Myc. Notes 4: 31 and photograph No. 81. The plants were found among dead leaves of deciduous trees and had the volva overgrown with white, mycelioid hairs. Otherwise they agreed with *Volvaria plumulosa*, as they had an even pileus and solid stem. The spores are said to be globose,  $5 \mu$  in diameter. The white, mycelioid base of the stem is not remarkable in plants growing among dead leaves.

2. *Volvaria umbonata* Pk. Bull. Torrey Club 26: 64-65. 1899. The species was based on plants found in Ohio by Lloyd, which grew in lawns and grassy places. It is illustrated by Hard, Fig. 194, who found it not uncommon at Chillicothe, Ohio. The species is distinguished from *Volvaria plumulosa* by its striate and slightly viscid pileus. In these respects, it agrees with *Volvaria parvula* Wein., from which it differs in the solid stem. The spores are  $4-5 \times 5-7 \mu$  exactly like those of *Volvaria Loweiana* and the other members of the group. Peck considers *Volvaria umbonata* as akin to *Volvaria media* but distinguished by the larger spores. The reports of the spores of *Volvaria media* may, however, be incorrect.

3. *Volvaria pusilla* Pers. It has often been reported from this country and is considered the same as *Volvaria parvula* Wein. The pileus is striate and viscid and the stem hollow, so that it represents the opposite extreme of the group from *Volvaria Loweiana*. It is also the smallest member of the group. The spores and basidia are characteristic of the group, as are in all

probability the cystidia also, the measurements of which are given in the Sylloge as  $6-7 \times 50-55 \mu$ .

All the members of the group agree in their fruiting bodies and in general appearance and color. They differ in various combinations of the characters, solid or hollow stem, even or striate pileus, and dry or viscid surface. *Volvaria Loweiana* is a case where parasitism has resulted in robust and luxuriant growth.

*Volvaria Loweiana* was collected by Prof. John Dearness at London, Ontario, Canada, in October, 1896, and distributed in North Amer. Fungi, No. 3509. In my specimen, the spores of the parasite are  $4-5 \times 6-8 \mu$ . No part of the host is present, but it is said to grow parasitic on *Clitocybe*. Prof. Dearness informs me that the host is *Clitocybe nebularis* and that the spores of the host measure about  $2.75 \times 5 \mu$ . He never found it on any other species. Lloyd's note in *Volvae* that *Volvaria Loweiana* was found on *Clitocybe monodelpha* is an error.

The host plant, *Clitocybe nebularis*, is very widely reported from both Europe and America, but the limits of its group are not well understood. Peck confines the species to plants with small spores,  $2-3 \times 4-5 \mu$ , and reports it as rare in New York State, having been found in only two or three localities. He illustrated it in Ann. Rep. N. Y. State Mus. 48: *pl. 23, f. 8-13*. Merrill in Mycologia, Sept. 1915, p. 268, says the spores of the European plant are  $5-7 \times 8-10 \mu$  and that Peck's illustrations are not suggestive of the European form.

There were two forms of the host of *Volvaria Loweiana*, both growing in the small area where the parasite was found. One is shown in *pl. 178, f. A, B*. The pileus was convex, whitish or with a slight tint of yellow, covered with a slight pruinosity, and often disfigured by dirt and humus. The lamellae were decurrent, adnate or even sinuate when young, becoming long-decurrent when mature. The stem was short, much thickened and often curved at the base. The spores were small,  $3-4 \times 5-6 \mu$ . The plants agree with the figures of Gillet and Britzelmayr except that the stems are shorter. Britzelmayr gives the spore measurements as  $4 \times 6-8 \mu$ . The second form is shown in *pl. 177, f. D*. It had a more equal stem gradually tapering upward, and the pileus was dark-smoky-gray. The spores were slightly smaller than in the

first form,  $2-3 \times 4-5 \mu$ . They agree with Peck's measurements, and also with those given in the Sylloge,  $2.5-3 \times 4-5 \mu$ , and by Stevenson,  $3 \times 4$  or  $3 \times 3-5 \mu$ . The plants also agree with Peck's illustration and in general with that of Masee in British Fungi and Lichens.

A very closely related group is that which contains *Clitocybe robusta* and *Clitocybe nobilis* of Peck, *Clitocybe candida* of Bresadola, and, in Quélet's opinion, also *Paxillus Lepista*. These plants, as I have seen them growing among leaves in open woods in Wisconsin, can scarcely be distinguished from the form of *Clitocybe nebularis* shown in *pl. 178, f. A. B.* They have a thick, white, convex to depressed pileus. The lamellae are adnate or sinuate to long-decurrent. The stems are usually short with much enlarged, often curved bases. The spores are, however, larger,  $4-5 \times 7-9 \mu$  in my specimens,  $4-5 \times 6-8 \mu$  and often slightly ochraceous in *Clitocybe robusta*,  $4-5 \times 7-8 \mu$  in *Clitocybe nobilis*, and  $3 \times 7 \mu$  in *Clitocybe candida*.

#### PILOSACE ALGERIENSIS (Fries) Quélet.

In *Mycologia*, May, 1913, pp. 167-169, I gave reasons to show that the mushroom parasitic on species of *Coprinus* and described in this country as *Panaeolus epimyces* Peck and *Stropharia copri-nophila* Atk. was the same as that illustrated by Lanzi, *Fung. Mang, pl. 67*, and identified as *Pilosace algeriensis*. During the past season, Dr. Mary S. Whetstone sent me several specimens of the plant found near Minneapolis, Minn., and from them I secured the photographs in *pl. 178, f. C, D* and *pl. 179, f. A.* A comparison with Lanzi's *pl. 67, f. b, c, d*, leaves no doubt that his specimens were parasites and the description proves their identity with the species before us. The lamellae of the parasite become wholly free from the stem as the pileus expands. The substance of the stem is not continuous with that of the pileus as can be seen in *pl. 179, f. A*, and the pileus easily separates from the stem. The plant has a universal veil which leaves the pileus and the base of the stem scaly, but there is no evident volva or annulus. The spores have a purple or brownish tinge rather than clear black. Hence the species is more naturally placed in *Pilosace* than in *Panaeolus* or *Stropharia* as was recognized by Fries, Quélet, and

Lanzi. *Pilosace algeriensis* appears to be very rare in Europe. Prof. Maire informs me he has never seen the species.

In addition to what has been said about the species by Peck, Atkinson, McKenna, Miss Sherman, and in my former article, some points regarding the effect of the parasite on the host plant are shown in these illustrations.

The carpophores of the parasite grow from the center of the pileus of the host either singly or in clusters. A comparison with the normal forms of the host, *pl. 179, f. C, D*, shows that the parasite has prevented the natural elongation of the stem. In very young carpophores of *Coprinus*, before the stem has begun to elongate, the gill chambers open outward and more or less downward with their bases and outer ends in the substance of the pileus, and their inner ends in that of the stem, although the exact point where the stem ends and the pileus begins, is somewhat arbitrary at this early stage of development. The mouths of the chambers are closed by the tissue of the veil, which is continuous with the trama of the gills. This is seen in Levine's figures of the young stages of *Coprinus micaceus*, *Amer. Jour. Bot. 1: pl. 39, f. 13-14* and *pl. 40, f. 9*. I have no photographs of the young stages of *Coprinus*, but the sections of *Agaricus arvensis*, *pl. 179, f. E, F*, are similar in the position of the young gill chambers. In *f. E*, the chambers point diagonally upward. Compare Atkinson's illustrations in the *Amer. Jour. Bot. 1: pl. 1*.

In normal non-parasitized plants of *Coprinus atramentarius*, the elongation of the stem and the simultaneous epinastic growth in the pileus results in a reversed position of the gill chambers so that when the pileus is formed and ready to expand the chambers lie in a vertical position with their bases outward and their edges towards the stem as in *f. D*. In plants which are parasitized, the elongation of the stem is inhibited and the enlarged gill chambers still lie obliquely upward with their mouths outward in the position which they have in the fully expanded carpophore of a mushroom of which the pileus becomes obconic or infundibuliform. Thus is formed the top-shaped mass of the host plant shown in the illustrations.

The substance of the veil which is left near the base of the stem in normal plants, *pl. 179, f. C*, becomes greatly thickened and

enlarged and covers the mouths of the gill chambers up to the margin of the pileus with a thick coat, *pl. 179, f. B*, and *pl. 178, f. C*. The base of the stem is also much thickened and does not become hollow. In many cases, there is a solid mass of parasitized stem, veil, and gill tissue and no annular gill cavity is formed, but often a more or less evident slit appears between the gills and veil as in *pl. 179, f. A*. This is the cleft observed by Lanzi and interpreted by him as connected with the formation of a ring.

The gills of the host plants attain nearly normal size and sometimes produce spores but are more or less parasitized. The substance of the pileus appears to be least affected and is not greatly thickened in the plants observed. The mycelium of the parasite causes the greatest deformation in the stem and the fruiting bodies are produced from the apex of the stem. This would suggest that the mycelium enters the host from beneath, but the method by which the *Coprinus* becomes infected is unknown:

I can offer no suggestion as to the group to which *Pilosace algeriensis* belongs nor to what non-parasitic mushroom it is nearest akin.

GENESE, ILLINOIS.

#### EXPLANATION OF PLATES CLXXVII-CLXXIX

##### PLATE CLXXVII

Fig. A. Two mature plants of *Volvaria Loweiana* growing from the deformed pileus of *Clitocybe nebularis*.

Fig. B. A single carpophore of the parasite showing the volva.

Fig. C. Two plants of *Volvaria plumulosa* taken from dried specimens.

Fig. D. Form of *Clitocybe nebularis* with nearly equal stem and dark-fuscous pileus.

##### PLATE CLXXVIII

Fig. A. Large plant of the form of *Clitocybe nebularis* with thick bulbous stem, white pileus, and decurrent gills.

Fig. B. Small plant with adnate or sinuate gills.

Fig. C. Deformed *Coprinus* with a single carpophore of *Pilosace algeriensis* growing from the center of the pileus.

Fig. D. Section of the host showing the depressed pileus with the parasite in the center, the enlarged base of the stem, and the thickened veil covering the edges of the gills.

##### PLATE CLXXIX

Fig. A. Vertical section of both the host and the parasite. The gill slit has been pulled open slightly. Compare with *Pl. 178, f. D*.

Fig. B. Outer surface of an infected host showing the junction of the pileus and the thickened veil.

Fig. C. Young carpophore of *Coprinus atramentarius* unaffected by the parasite.

Fig. D. Vertical section showing the position of the gills when the pileus begins to expand.

Fig. E. Section of a young carpophore of *Agaricus arvensis* showing the position of the gill chambers.

Fig. F. Section of a somewhat older carpophore in the growing state, showing the lines of growth, position of the gills and the partial veil when the stem begins to elongate.